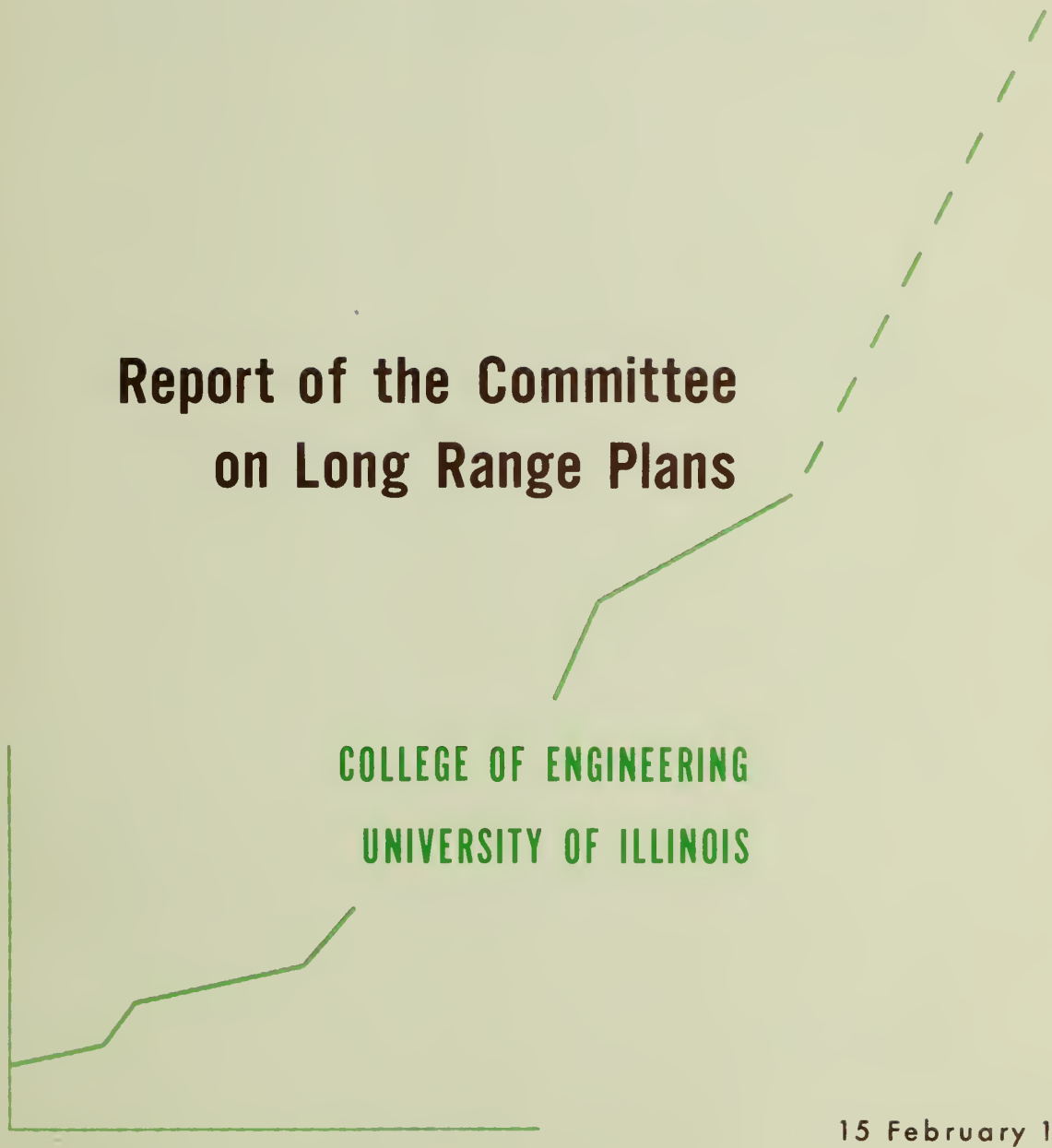
ILLINOIS UNIVERSITY COLLEGE OF ENGINEERING

COMMITTEE ON LONG RANGE PLANS REPORT

Report of the Committee on Long Range Plans



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UNIVERSITY OF ILLINOIS

15 February 1962

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SUMMARY OF PRINCIPAL RECOMMENDATIONS

Engineering curricula must meet the requirements not only of present but also of future engineering practice. However trite such statements have become, they are the real challenge of engineering education. This report attempts to define the major problems in meeting this challenge and to make recommendations for the future development of the College of Engineering of the University of Illinois. This summary of principal recommendations is arranged according to the divisions of the report.

Organization of the College: The continuing need for engineers well trained in the basic technology of traditional fields, the maintenance of strong relationships with professional engineering societies, the limitations of alternative over-all plans of organization suitable for a large state university, and the difficulties inherent in a rapid transition to a new structure, lead to the recommendation that present departmental structure of the College be retained, but experiments with new structures should be initiated.

Development of New Programs and Facilities: Provision should be made for the development of new groups and experimental programs, particularly those of an interdepartmental nature.

Future Student Body: In the face of expected heavy enrollments and limited numbers of qualified teachers, strong consideration should be given to higher standards for admission to the Engineering College. An examination board should be appointed to establish qualifying examinations for entrance into the junior year. To realize full potential from the best students, honors programs should be enlarged and strengthened.

Faculty Development: The College should establish an organized plan for faculty development in teaching, research, and other professional activities. Each department should establish procedures for training new teachers and improving teaching at all levels. As far as possible, each faculty member should participate in undergraduate teaching.

Individual staff research should be encouraged by obtaining more funds for such research and for increasing the number of open Experiment Station assistantships.

Sabbatical leaves should be encouraged, and present policy should be modified to allow work on advanced degrees during a sabbatical leave.

Distinguished authorities should be brought to the campus on temporary appointments, and increased emphasis should be placed on holding scientific meetings on campus. Travel to off-campus meetings by faculty should be aided as much as possible.

Graduate Study and Research: The graduate study and research programs should continue to expand. In certain areas of engineering, programs should be developed that emphasize broad knowledge of public policy and social problems combined with a high level of technical competence.

Undergraduate Curricula: Engineering curricula should place strong emphasis on the sciences while not neglecting design. The first year of all engineering curricula should be identical and the second year compatible,

in recognition of the essential unity of all engineering fields.

High speed digital computers have become indispensable to engineering. A course in computers should be taken by all engineering students during their sophomore or junior year. Steps should be taken to encourage faculty training in computers, so that computer techniques can be fully incorporated in advanced courses.

Engineering Technicians: The value to the engineer of well trained technicians makes it important for the College to maintain close liaison with the technician training program in Illinois, to cooperate with the College of Education in developing teacher training in this area, and to support the establishment of technical institutes in Illinois.

Applied Mathematics: The College of Engineering should encourage and assist the Department of Mathematics in all appropriate ways in the development of a strong group in applied mathematics. To this end, the College should request the Department of Mathematics to establish a Division of Applied Mathematics. Studies should be made of the feasibility of joint appointments between the College and this Division.

Social Sciences and Humanities: The humanities and social sciences must be recognized as essential for a truly professional career in engineering. Therefore, the College should take all appropriate steps to insure that engineering students receive a meaningful education in both the social sciences and humanities.

Specifically, a standing committee should be established in the College which, in consultation with representatives of other areas, shall select courses and course sequences to insure valuable experiences for engineering students in both the humanities and the social sciences. All undergraduate curricula should include a minimum of 18 credit hours in the social sciences and humanities, involving work in both areas.

REPORT OF THE COMMITTEE ON LONG RANGE PLANS

1. INTRODUCTION

Engineering educators generally accept the principle that curricula cannot be based on contemporary practice. Changes in technology during an engineer's professional career are so great that such an education would be completely inadequate. However, the changing requirements and the rapid advancement of science present the educator with an ever widening spectrum of problems. This report will attempt to define the major problems and to make recommendations for the future development of the College of Engineering at the University of Illinois better to meet the needs of the future.

The Committee on Long Range Plans was appointed by Dean W. L. Everitt in September 1959. It held periodic meetings and discussions during the year, and had the benefit of advice from faculty members who met with it by invitation to review certain aspects of the organization of the College, and to present future plans of the various areas and departments. A preliminary draft of the report of the Committee, dated 8 December 1960, was distributed to the faculty and discussed at a meeting at Allerton on 13 and 14 January 1961 with a representative group of some 50 staff members of the College. A second draft was distributed to the faculty in November 1961 and discussed again with a group of 80 faculty members at a meeting at Allerton on 15 and 16 December 1961. This report is the outgrowth of the discussion at these meetings, reports and comments by working groups at the meetings, and further discussions among the Committee.

New developments in the sciences closely related to engineering seem certain to alter materially the traditional groupings into professional fields as we now know them. Even now, a re-orientation of curricula is needed. Such a re-orientation must emphasize the unity of the engineering profession, yet permit education in depth, with specialization in appropriate areas. Hence, the organization of the College of Engineering must facilitate interdisciplinary approaches in new fields, at the same time permitting efficient management of the program of a large engineering school.

Because new programs to meet new needs will require continual development, provision for the organization of special groups must be included in the organization of the College. Because physical facilities must expand with the growth of the engineering program, development of facilities must keep pace with other

developments.

The increased emphasis on graduate education in engineering and the rapid growth of graduate enrollment relative to undergraduate enrollment have caused a change in the pattern of the student body. Provision must be made for the growth of the College and for this increased emphasis on graduate work. Demands of the future and limitations on space and facilities will require consideration of methods for evaluating the undergraduate as well as the graduate student. Attention must be given to proper counselling, guidance, and selection of students at all levels.

Rapid advances in science and technology make it necessary to select new engineering faculty with careful attention to their potential for growth. Opportunities must be provided the faculty for special training to keep abreast of these advances. Because of the inadequate supply of young engineering faculty with superior qualifications, means must be found to attract into the teaching profession a sufficiently large number of bright young engineers and scientists.

The problems of graduate study, research, and undergraduate curricula are all closely related. The flow of knowledge in technical areas is largely from research, through graduate teaching, to undergraduate teaching and thence into technician training. Provision must be made for the rapid filtering of scientific and engineering advances into the educational process throughout the program. The undergraduate engineering curriculm must continue to develop to take account of the better preparation of incoming students from the secondary schools.

The importance of applied mathematics in the education of engineers requires that special consideration be given to this topic. Also of great importance is education in the humanities and social sciences throughout the undergraduate career and beyond for the engineer who aspires to leadership in his profession. Greater attention to this part of the prospective engineer's education is of the utmost importance.

2. ORGANIZATION OF THE COLLEGE

New developments in engineering and science require continuous revision of subject matter in educational programs. The increased emphasis on science and mathematics in professional curricula results in a growing similarity in the major objectives of these curricula. Emphasis on the education of engineering students in the social sciences and humanities, together with an increased competence in science, reduces the time available in undergraduate curricula for courses which are highly specialized along professional lines. The trend at some schools is toward offering one baccalaureate degree in engineering with provisions for majors having different professional orientation. Furthermore, the changing emphasis in engineering education directs attention to the question whether the professionally oriented departmental structure is the most effective organization.

Recent specific revisions in educational program and college organization can be illustrated by the following examples:

The California Institute of Technology has discontinued professional undergraduate degree designations and now offers two baccalaureate degrees, one with a science designation and the other with an engineering designation. Options offered during the fourth year enable students to emphasize particular professional fields or technical areas. The graduate programs retain professional orientation.

At the Massachusetts Institute of Technology interdisciplinary functional groups in various areas are being developed with the intention of replacing eventually the traditional professionally oriented engineering departments.

The Johns Hopkins University has announced that it will combine its mechanical, civil, and aeronautical engineering departments into one department of mechanics.

In these institutions the numbers of undergraduate engineering students are smaller than at Illinois. Their students are also probably more homogeneous in ability and interests. The institutions are less comprehensive in scope that Illinois, with its commitments as the principal source of practicing engineers in a state with a demand for engineers in agriculture, construction, conservation and utilization of natural resources and products, light and heavy manufacturing in great variety, public utilities, and other areas.

In contrast, the College of Engineering at the University of Illinois must for the near future not only continue to graduate many engineers in the traditional

fields, basically prepared for the present wide range of engineering practice; it must also move into new areas of education and research and toward new groupings among faculty from the traditional departments, in order best to prepare research and practicing engineers to work in the areas which will become increasingly important over the next ten years.

Factors which favor retaining the present departmental structure at Illinois include the continuing need for engineers well trained in the basic technology of the traditional fields; the maintenance of good relationships with the professional engineering societies, which contributes to faculty and student morale; the limitations of alternative over-all plans of organization considered by the Committee; and the difficulties inherent in a rapid transition to a new departmental structure. For these reasons, the Committee recommends the retention of the present departmental structure, at least for the near future. However, experimentation with other types of departmental or group structures is recommended, particularly those related to desirable interdepartmental or interdisciplinary programs of education and research. The College is large enough to permit experimentation without interruption of existing programs.

As a matter of fact, there is at present a substantial amount of interdepartmental activity in the Engineering College at all levels of instruction and in research. Such activity in research, which is developing more rapidly and along broader lines than in instruction, should be encouraged with the view that it will serve as a catalyst in the development of both undergraduate and graduate interdepartmental educational programs.

In addition to encouraging important interdepartmental and interdisciplinary activities in the Engineering College, the Committee calls attention to the value of interdepartmental cooperation in attracting to the campus national conferences and meetings of high scientific level, and in promoting industrial and alumni support of education and research programs.

The Engineering Experiment Station is a potentially effective force in uniting the teaching and research functions in the Engineering College, and its coordination of large and diversified research activities has given vital aid to the educational programs in the College. These highly beneficial effects are, to a large extent, the result of the Experiment Station being an integral part of the Engineering College.

The close relationship between contract research and the educational program, resulting from the organization of the Engineering Experiment Station within the

College, has permitted staff members to combine teaching with research in a manner that has greatly strengthened our graduate and undergraduate instructional programs, and has also enabled us to attract unusually competent staff members to positions on our faculty. However, in order to continue the building of permanent staff, it is essential that additional senior staff positions with tenure be underwritten by the University in order that outstanding men can be acquired when and if they become available.

3. DEVELOPMENT OF NEW PROGRAMS AND FACILITIES

Although the Committee believes that the department will continue to be the basic unit in the organization of the College of Engineering for the immediate future, it has envisioned the increasing prominence of functional areas which cut across traditional departmental and even college boundaries. Such functional areas, either oriented toward a single field of study in one or more departments or oriented toward an interdisciplinary subject involving a multiplicity of fields and departments, define themselves in the rapid development of science and create the need to cope with new challenges through a re-orientation and reorganization of scientific talent and facilities. New programs may grow from within the College or Departments or by development with the help of new staff recruited for such purposes. Departments may have sufficient flexibility to adjust to ordinary and foreseeable trends in their own respective areas of activity, but the need to react promptly and properly to developments will make special new groups and experimental programs of critical importance as a means of guiding and accelerating the evolution of the College of Engineering.

Every effort should be made to provide effective communication through seminars, discussions, etc., in order to identify and promote a community of interest and establish an attitude from which new groups or programs may emerge.

Interdepartmental or interdisciplinary groups may be formed on various bases. Four possible types of foci of such programs, not all mutually exclusive, are the following:

1. An area in a basic field of knowledge, with a fundamental theoretical structure of its own, which has wide application in a number of engineering fields. Examples are:

   Transfer and transformation of energy

   Information processing

   Fluid mechanics

2. A defined new field of technology, as for example,

   Nuclear engineering

3. A project-oriented research program which requires a high level of talent from theoretical and experimental engineers and scientists from two or more departments or disciplines. Systems engineering

might frequently develop problems in this category. A good example is the research on electromagnets making use of superconductors now being initiated in the Coordinated Science Laboratory. It has problems to challenge the mechanical, electrical, and structural engineer as well as the physicist.

4. The research laboratory or facility with a broad but bounded inter-departmental or interdisciplinary area of interest. Examples are:

   Digital computers
   Materials science
   Materials engineering
   Environmental engineering
   Aero-space engineering
   Bio-engineering

Interdepartmental programs on one of the bases described above, particularly in a basic field of knowledge, or a newly defined field of technology, may eventually lead to a new department that might involve realignment of present departments. The intermediate steps would include the organization of research seminars; the offering of basic courses, perhaps cross-listed in two departments or more, coordinated with or replacing existing courses; the establishment of new graduate degrees on the basis of a core of related courses and thesis research, and of a major for a bachelor's degree. One can thus imagine a focus of activity developing first on the faculty and graduate level, and finally into a full-fledged education and research program or department, as a field develops from novel application of basic science to engineering practice.

The initiation of new ventures of the kinds described should be encouraged. At the same time present programs of education and research of high quality and usefulness must be kept going. Certain ground rules should be met by new departures before scarce space and financial resources are allocated to them:

1. A group of interested faculty members with a common or overlapping active research interest and with demonstrated research ability, must be available. Strong leadership by one individual is often desirable.
2. In the formative stages association and active cooperation with one department is desirable, to provide service facilities (secretarial, shops, supplies, etc.) and administrative liaison.
3. Unless or until a new curriculum or formal teaching program is developed, the faculty involved should teach and engage in supporting

activities in an established department. Walled-off research institutes should not be allowed to develop. New developments should be brought into the departmental teaching programs as rapidly as practicable.

Since the need for a new group or program presupposes a novel or extraordinary situation, financial, space and personnel problems may often arise. The most appropriate form of organization will depend upon the special purpose and character of the effort, but a transient rather than an ultimate form of administration will often be desirable. New groups and experimental programs will probably emerge as a consequence of personal or group effort. Such groups achieve formal status through action by the Dean. Their activities may be controlled by committees appointed by and responsible to the Dean, or if it appears appropriate they may report to the Dean through existing departments. The Dean should review the status of new groups and programs to determine whether their development warrants elevation to an independent departmental level, or whether their functions can or should be properly absorbed by existing departments or groups.

Regardless of official status, interdisciplinary groups and programs which straddle the disciplines of traditional departments are most useful devices for promoting development of the College. The joint appointment of faculty members to more than one department is particularly appropriate in dealing with the interdisciplinary nature of experimental groups and programs.

The Committee believes that the mechanism for initiating and implementing new and improved educational and research programs now exists in the College, and it urges vigorous and farsighted application of these provisions in the future.

The development of new groups may often require new facilities and equipment. Because capital expenditures for facilities and equipment are a continuing need of existing departments, administrative procedures for the allocation of funds must be considered. Although this administrative problem is appropriately the province of the Dean, there is a related matter of representation of the new groups on such committees as the Executive Committee of the College or the College Policy and Development Committee. If a complete representation of all groups is attempted, these committees will become unreasonably large; they are probably too large now. Therefore, the Committee recommends that the Dean consider establishment of control groups or subcommittees for these large administrative committees when in his judgment this appears necessary.

4. FUTURE STUDENT BODY

A long-term trend of greatly increased enrollment in engineering at the University of Illinois seems likely despite minor fluctuations. Estimates made by Dean W. L. Everitt in "Public Higher Education in Illinois" (Staff Report to the Committee to Recommend the State Plan for Public Higher Education, published by the Illinois Joint Council on Higher Education, Springfield, 1961, pages 69-77), indicated a growth in the undergraduate enrollment exclusive of physics, in the years between 1960 and 1975 from 4,300 to 6,000 students, and in graduate enrollment, from 815 to 2,600, assuming that the University of Illinois at Congress Circle, Chicago, develops a four-year engineering program by 1965. The projected enrollment estimate shows clearly the need to expand engineering educational facilities at Urbana. Furthermore, it must be emphasized that future engineering college output for the nation may well be limited by the availability of qualified teachers rather than by a lack of qualified students.

The emphasis on graduate work is consistent with the recommendations of the University Study Committee on Future Programs, which has suggested that the University enrollment be guided toward a 2-3-2 ratio between the lower undergraduate (i.e., freshman, sophomore), upper undergraduate (junior and senior), and graduate levels. A growth rate of the order of 15 percent per year in graduate enrollment has been in evidence for the past several years at Urbana. The Committee believes that this trend is desirable and should be encouraged. To this end there should be a careful selection of the limited number of students admitted at the freshman level. It also appears advisable to provide a qualifying examination before admission to the junior year in Engineering.

Effective September, 1961, a high school graduate in the lowest quarter of his graduating class (lower half beginning September 1963) will be admitted only after presenting one of the following three evidences of ability to do satisfactory work at the University:

(1) Obtaining a passing score on a test prescribed by the All-University Committee on Admissions.

(2) Successfully completing 12 or more semester hours of work at another college or university of recognized standing, and meeting the regular University requirements for admission as a transfer student.

(3) Applying for admission to a session which begins at least twelve

months after graduation from high school, provided that in this period he has not attempted as much as twelve semester hours of work at another college or university.

Effective September 1961 priorities for admission were established, based on rank in high school class, or alternatively, on test scores obtained on tests designated by the All-University Committee on Admissions.

The All-University Committee on Admissions has considered it possible to establish different priorities for different colleges, or even different departments. The Long Range Plans Committee recommends that strong consideration be given to setting higher standards for admission to engineering.

Entrance requirements and qualifying examinations for upper level undergraduate students and for graduate students may be needed to control the pattern of enrollment and to avoid overloading inadequate facilities with poorly prepared students. The Committee recommends that qualifying examinations be established, to be given to all undergraduate engineering students before they enter the work of the junior year.

To establish the proper type of qualifying examination, and to determine the difference, if any, in the evaluation of the work of those students who have completed their first two years on the Urbana campus compared with those transferring from other schools, the Committee recommends the establishment of an examination board to develop the type of examination and to administer the examinations after the studies of the type and required level of achievement have been completed. The Committee recommends further that these examinations be started soon, but be used for diagnostic purposes only for a period of three years until sufficient experience with results has been acquired.

5. FACULTY DEVELOPMENT

The strength of a university lies primarily in its faculty. Therefore, careful consideration must be given to providing adequate salaries, facilities, the appropriate research atmosphere, and other means of support to attract and hold an outstanding staff and simultaneously encourage continued and improved staff productivity. Our staff must have the ability to foresee the future scientific and technological advances and must lead in making new discoveries as well as in the education of students as modern engineers and scientists.

Faculty development can include teaching, research, writing, service in national organizations, training of technicians, career guidance, dissemination of scientific information through local colloquia and other meetings, and general leadership in developing new scientific approaches. Specialization in a single activity is not in the best interest of a progressive academic atmosphere.

The faculty member with an appointment primarily of a research nature should not feel he can justifiably isolate himself from all other areas of academic development. Similarly, although some staff members will have interests primarily in teaching, they cannot be progressive engineers, scientists and educators unless they are also active in areas other than teaching. The value of industrial consulting and experience obtained through summer positions in industry should be recognized in considering the balance of activities necessary for faculty development.

Faculty development on a voluntary basis is difficult without an organized plan of encouragement. A desirable goal might be a periodic reduction in the teaching load of selected staff members to give free time for concentrated study in an area of the man's choice. This arrangement should be an addition to the regular sabbatical leave program, and the request for reduced load should be accompanied by a plan of proposed study.

With the envisioned increase in enrollment in the near future, the demands on the staff for teaching both undergraduate and graduate courses will be increased. Teachers of science and engineering will be in short supply for the years to come. Competition with industry and other universities will give added emphasis to high quality. Since much progress in engineering will require teamwork, the emergence of functional groups within and across departmental boundaries should be encouraged. Such groups will provide for the orderly

evolution of the organizational structure and assist in faculty development by creating an atmosphere of increased resourcefulness, continuous stimulation, and opportunity for developing leadership. Increased budgetary allotments for additional staff are important if the staff is to have adequate time for research. In general, teaching loads should be made flexible so each staff member can have time available for other professional activities. Research is of utmost importance for staff members guiding the work of graduate students.

It is recommended that, as far as possible, each staff member participate in undergraduate instruction. This can be accomplished by establishing a rotation plan for course instruction.

Although members of the staff of the College of Engineering have been able to devote a substantial amount of time to research or comparable creative work, much of the support for this research has come from contract funds. This is not an unhealthy situation. Nevertheless, the funds available in the recurring budget must be sufficient to permit the development of new research areas, even when contract sponsorship is not available. Moreover, additional funds are needed for research assistantships to enable the staff members to make better use of their time, and to permit more graduate students to have research experience as part of their graduate education.

Those staff members who do not demonstrate capability in their technical field, or who do not have the vigor and creative imagination associated with achievements in science and engineering, should be discouraged from continuing their careers at the University. A full-time staff member who does not give evidence of the qualifications required for a tenure position should not be encouraged to remain on the staff longer than five years as an assistant professor. However, the Committee does not favor an automatic "up-or-out" policy for promotions.

Teaching

The importance of good teaching should be emphasized. Because of the continuous evolution that is a vital part of engineering teaching, good teaching involves much more than merely presenting a well organized, clear lecture. The teacher must be aware of new developments in this field and must have the ability and desire to keep course content continuously up-to-date. This is the reason for the necessity of a balance between teaching and other activities. Strong encouragement should be given to research and organized studies to improve the effectiveness of teaching on all levels from freshman

courses up through graduate courses.

For development of good teachers and good teaching, it is recommended that procedures be established in each department for training new teachers and improving teaching at all levels. It is desirable as a department policy to have the teaching activities of assistants and junior staff members monitored and guided by the senior staff.

The College of Engineering should be genuinely concerned with faculty development and improvement of teaching at the junior colleges throughout the State, since these teachers will be supplying the basic training for many of the students coming to the University of Illinois.

Research Activities

One strong indication of a progressive and healthy attitude in an engineering faculty is active interest among the majority of the staff in conducting research. Although the Committee is highly in favor of group efforts in carrying out advanced research programs, such as those anticipated for the Materials Research Laboratory, it feels that a concentrated effort should be placed on supplying facilities, support, and encouragement for research instituted by individual staff members or by small groups or teams. The Committee opposes the use of University facilities or funds for routine testing types of research for industry, and also any type of research that has strong limitations as to purpose, scope, or publication placed on it by an outside agency.

To encourage individual staff research, a concentrated effort must be put into securing more funds for open graduate research assistantships and for new research programs. These funds should be particularly useful in helping young or new staff members initiate programs, and they should in no way be tied into a preference that the research investigator already have a research contract.

At the present time, the Engineering Experiment Station serves a useful function of coordinating and servicing research in the College of Engineering. The Committee feels that the Experiment Station should be one of the greatest single centers for support of scientific and engineering research in the country. To achieve this aim, budgeted funds for development of new research programs should be provided. The present number of open research assistantships available through the Experiment Station should be at least doubled or tripled as one step in encouraging faculty development. The emphasis, however, should not

be placed on merely expanding the number; the emphasis should be on attaining a modern research philosophy -- a philosophy that will insure our having a staff of the highest ability who will be leaders in future developments and in attaining the highest level of scientific training for our students.

An important facet in carrying out high level scientific activities is the availability of well-trained technicians to service the various facilities. Additional funds should be provided to extend greatly the ability of departments, special groups, or individuals to employ high-calibre technicians for research or other projects.

Sabbatical Leaves

The Committee feels that an arrangement whereby faculty members can take regular sabbatical leaves is essential for the development of an outstanding staff. A sufficient number of faculty members should be available to make it reasonable for individuals to feel free to request a sabbatical leave for advanced scientific investigation. The sabbatical leave program should be modified to make it possible to obtain a leave in order to do work on an advanced degree.

Visiting Scientists

Increased emphasis should be placed on bringing in visiting professors and scientists who are outstanding authorities in their fields for one-semester or one-year appointments.

Special Scientific Activities

A greater emphasis should be placed on holding scientific meetings and special short-term scientific sessions on the campus. Although non-technical activities are certainly acceptable and worthwhile, the Committee feels that public relations and adult education activities should be supplemented by promoting on our campus meetings of an advanced scientific nature to attract outstanding scientists.

Strong efforts should be placed on a program in which the faculty receives support to go to special off-campus sessions for new contacts and ideas. This is the type of activity currently supported by the Ford Foundation, and is essential to staff development.

In considering the general problem of faculty development for the future, the Committee wishes to emphasize that every effort should be made to encourage faculty development along the line of advanced scientific knowledge, because this is essential to keep courses and curricula up-to-date. Other

areas are important also, but special emphasis should be placed on the scientific area.

6. GRADUATE STUDY AND RESEARCH

The University of Illinois has a long history of strong graduate programs in engineering. It is second in the nation in the number of Ph.D. degrees granted in engineering from 1953 to date, and has been first in the country from 1947 to date in the number of Ph.D. degrees in civil engineering. One out of every five engineering students at the University of Illinois, Urbana, is in a graduate program. Concurrently, engineering research at Urbana has grown to nine million dollars per year, with only a small portion coming from the recurring budget. A strong research program is essential to the support of graduate students in engineering and the physical sciences.

Because of the urgent need for more engineering teachers with advanced training, and because of the necessity for more advanced training on the part of those engineers who can be classed as creators or designers, the University of Illinois should continue to expand and extend its program in graduate study and research. Moreover, research associated with the graduate study program develops the capabilities of the teaching staff responsible for the undergraduate curricula. The atmosphere of research and graduate study is a healthy one for the undergraduate student, and contributes to his education in a way beyond that measured by courses and curricula.

In certain areas of engineering, the Committee believes it desirable to develop programs which emphasize a broad knowledge of public policy and social problems combined with high level technical education. Such areas include transportation, urban planning, water resources, management, and the like, where qualitative rather than quantitative solutions are involved. These problems must be approached in an interdisciplinary fashion involving economic, sociological, political and other human factors.

7. UNDERGRADUATE CURRICULA -- TECHNICAL CONTENT

Intellectual creativity and inventiveness are dominant characteristics of the engineer. He must be able to relate and bring together events of nature in quantitative ways to formulate new and useful theories, and to develop new materials, devices, or systems, especially systems in which men interact with machines.

To accomplish this, the curriculum must include science and the scientific method, and must provide, through synthesis and insight, quantitative models, or mathematical theories, in which are brought together in logical sequence the multitude of observed natural phenomena. This quantitative organization of physical phenomena is the key to engineering analysis and synthesis. The curriculum must also teach engineers how to predict the performance of new designs, and must enhance their ability to devise new applications.

To prepare engineers for successful careers, the curriculum must place a strong emphasis on the sciences. The basic sciences (mathematics, physics, and chemistry) are essential, but a wide coverage of all of the engineering sciences (electrical theory, nature of properties of materials, mechanics of solids, mechanics of fluids, and thermodynamics) are equally necessary.

The emphasis on science should not imply that "design" is not important. The application of scientific principles toward the benefit of society is one of the identifying characteristics of an engineer. The real challenge for engineering educators is to develop design and synthesis courses that supplement and enrich the material that has been presented in earlier courses in the basic and engineering sciences. Problems that have no unique or "correct" answer should be introduced as early as possible. While the importance of mathematics should not be minimized, students should become acquainted with the fact that many important engineering decisions cannot be made solely from mathematical considerations. A great deal of engineering judgment and skill is often needed to formulate the mathematical model of the problem.

To make room in a four-year program for the important new material, the College must decrease the number of hours devoted to such other topics as the routine skills intimately associated with the practice of professional engineering (i.e., surveying, drafting, machine tool operation, etc.). Also, repetitious coverage of subject matter in various courses should be minimized.

However, the development of the student's knowledge of the humanities and social sciences must not be overlooked.

The fundamental scientific basis for engineering education, and the engineering science and the humanistic and social studies requirements, provide a group of courses common to all branches of engineering. The relationships among the various branches of engineering, in carrying out the types of work that will be needed in the future, require closer contacts among different fields. Many of the old distinctions between these branches have vanished. There are close relationships, for example, between the machine designer in mechanical engineering and the structural designer in civil engineering, or the aircraft structures engineer.

While early selection of an engineering field by the students may offer certain advantages such as motivation and esprit de corps, these factors must not be allowed to detract from the unity of the engineering profession and common knowledge shared by all engineers. In recognition of this point, the committee recommends that the first year of all engineering curricula be identical and that the second year be "compatible." That is, courses taken during the sophomore year by a student in one curriculum should be acceptable for credit toward graduation if he transfers to another engineering curriculum. It may not be possible to develop a single compatible two-year program. However, it seems feasible to develop one program for those areas of engineering with a basis primarily in physics and mechanics, and a second program for those fields with a basis primarily in chemistry.

The primary consideration in preparing curricula must be the establishment of excellent four-year programs for students who enter the University as freshmen. Consistent with this thought, however, every effort should be made to minimize inconvenience and loss of credit for students who transfer from one area to another during the first two years. Course sequences should be avoided that require more than one course in the sophomore year, as a prerequisite to advanced work in a particular field, which does not fit into other curricula in the college. Our program should develop advanced independent scholarship in our students rather than merely subject them to a sequence of courses.

The Committee recognizes that common programs covering the whole field of engineering, although desirable in many respects, are likely to lead to a freezing of the pattern of the curriculum in such a way that changes will become more difficult. Every effort should be made to avoid this difficulty. Frequent

reviews of curricula, and necessary changes, are to be encouraged so that the results of technical progress can be given appropriate and timely attention.

Programs for Superior Students

There will be an increasing need for programs which offer a challenge to unusually qualified students. Further development of honors programs for the upper ten to twenty per cent of the undergraduate students should be considered. Honors programs should permit unusually qualified students, with appropriate advice and guidance, to take special courses of study, as well as to permit them to go further and faster than their colleagues. Experimentation with curricula, including course content and methods of teaching, could well be based upon experience gained in working with honors students. This will have many beneficial effects upon all programs in the College. Positive steps should be taken to attract more students capable of carrying honors programs.

Use of Computers

The high-speed digital computer has become an indispensable part of engineering, and means should be developed for integrating the computer into the educational and research program throughout engineering. Therefore, a course on high-speed digital computers should be taken by all engineering students during their sophomore or junior year. Because the benefits of early courses on computers will be greatly influenced by the effectiveness with which the applications are included in subsequent courses, adequate facilities must be made available so that computer work can be integrated into the courses of the junior and senior years.

In recognition of the fact that the widespread usage of computers has come about since most of the faculty completed their formal training, special steps should be taken immediately to encourage faculty training in this area. Special courses on high speed computers should be provided for efficient utilization of faculty time, and released time should be made available so that they can acquire the knowledge and experience to utilize computers as a meaningful portion of appropriate junior, senior, and graduate level courses.

Design and Laboratory Courses

A danger exists in the trend toward a more scientific basis for engineering that both students and faculty will become excessively preoccupied with mathematical analysis or with the exposition of important fundamental topics for their own sake. In many respects engineering is a creative art. The curriculum must

convey to the student the vital facts that engineers design things and that these designs must of necessity involve judgments and compromises. The most skillful teaching of merely the science that underlies engineering is not enough. This must be supplemented by a sort of creative experience which is the aim of courses in design or of modern laboratory concepts.

The teaching of concepts of design and experience in the laboratory can develop the engineering outlook and emphasize the art of solving problems creatively. The Committee recommends that consideration be given in all departments to a revision of the laboratory program to stress fundamental concepts and ideas rather than conventional equipment and machines. Stereotyped experiments should be avoided and give way to more imaginative approaches in which students are given an opportunity to undertake pertinent projects of their own choice and to benefit from a kind of internship by participating in real and difficult problems.

8. ENGINEERING TECHNICIANS

The revolutionary discoveries in science and technology have decreased the manpower needs for the semi-skilled and greatly increased the needs in the technical categories. The demand for adequately trained technicians as aides to the professional engineer is expected to triple in the next 15 years.

Recognizing this need, the Office of the Superintendent of Public Instruction initiated, in September 1958, a study of vocational and technical education in the State of Illinois. Recommendations of the study, particularly germane to this report, call for the establishment of a system of comprehensive junior colleges, ten in all, strategically located with reference to population distribution, means of transportation and geographic and sociological factors.

The several centers would provide technical and college transfer curricula (the majority requiring two years of full-time study) as well as an opportunity for adult education in the region.

The College of Engineering is cognizant of the need for technicians and appreciative of their value to the engineering profession. Further, it is recognized that the technician training program may be the most satisfying educational experience for many young people. However, in view of the regional nature of the several centers and their affiliation with the Office of Public Instruction, the committee believes that it is neither desirable nor expedient for the College of Engineering to engage directly in technician training programs. Rather, the scope of the technicians activities indicates the need for close liaison with the College of Engineering.

The development of college transfer curricula involving engineering credit courses would place on the College of Engineering the obligation to review entrance requirements, and to advise and counsel on such matters as course proposals and sequences, standards of performance and staff qualifications.

Relative to the latter, the Committee believes it advisable to establish a working relationship with the College of Education in developing courses for the training of the technical institute staffs.

Further academic relationships may arise in transfer from university programs to technician training courses if such transfer appeared best in the student's interest.

With regard to the training of technicians, the Committee makes the following recommendations:

1. While there should be no direct adminstrative relationship between the several centers and the College of Engineering, a strong and formal advisory relationship is desirable to provide for effective liaison.

2. That the existing Technical Institute Curriculum Advisory Committee have its responsibilities defined in such a manner as to provide a loose and flexible organization to deal with future problems such as teacher training, curriculum supervision and any other problems that may become important to the College of Engineering. It is recommended that the College of Engineering cooperate actively with the College of Education in the development of the program for the training and upgrading of technical institute staff.

3. That the College of Engineering express its approval of the establishment of a series of technical institutes throughout the State of Illinois. These should be organized to grant an associate degree upon the completion of a two-year curriculum. The curricula should be structured so as to satisfy E.C.P.D. accreditation criteria.

9. APPLIED MATHEMATICS

An effective University program in mathematics is of critical concern for the College of Engineering. The most effective teaching and the highest quality of research in mathematics must be sought by the College. There has been a persistent belief within the College that the present teaching of mathematics to undergraduate engineers leaves much to be desired and that a stronger program of graduate training and research in applied mathematics should be encouraged.

The location of the Department of Mathematics within the College of Liberal Arts and Sciences, where the College of Engineering lacks direct control over its activities, poses special problems for the College of Engineering. The creation of a special group or a Department of Applied Mathematics within the College of Engineering has been suggested as a solution to these problems.

The Committee does not believe that such a step will best serve the interests of either the College of Engineering or the University. Many of the problems of the Department of Mathematics are not subject to their control and would be encountered by any other group. There exists a serious shortage of competent mathematicians. The budget of the Department of Mathematics has been, undoubtedly, inadequate for many years.

There are, moreover, many disadvantages in having two independent groups of mathematicians on the campus. Competition for funds, faculty, and students will inevitably result.

This Committee does not feel that a division of mathematics into pure and applied disciplines is sufficiently realistic with respect to either teaching or research to serve as a satisfactory basis for separate departments. There are very real benefits in having mathematics taught to engineering students in a department where mathematics is cultivated for its own sake. There is a very real danger that a Department of Applied Mathematics created explicitly to serve the needs of the College of Engineering would never rise above mediocrity.

The nature of applied mathematics is such that its teaching and practice are widely diffused throughout the University. The activities of the Digital Computer Laboratory of the Graduate College, for example, are a form of applied mathematics. It is neither possible nor desirable to attempt the segregation of all applied mathematics within a single department. Cooperative

effort by the mathematicians, engineers, and physicists appears to be the natural solution to the problem of strengthening applied mathematics on the campus. This Committee does feel, however, that the University lacks a focal group for the encouragement of such activity.

The Committee recommends that the College of Engineering request the Department of Mathematics to establish a Division of Applied Mathematics. This Division would serve as a center for cooperative activities and should enhance the prestige of applied mathematicians on campus. It should help to attract additional distinguished applied mathematicians and funds for their support. This Committee suggests that the assistance and advice of the Graduate College Committee on Applied Mathematics be enlisted in the development of the applied mathematics program.

This Committee further recommends that the College of Engineering establish effective, continuing liaison concerning the organization and teaching of undergraduate mathematics courses for engineers, and examine the feasibility and merits of joint appointments between departments of the College of Engineering and the Department of Mathematics. By this means the College of Engineering could give more than just moral support to the Department of Mathematics.

10. SOCIAL SCIENCES AND HUMANITIES

The humanities and social sciences must be recognized as essential for the foundation of a genuinely professional career in engineering. The products of the engineering profession have great human and social consequences, and science and technology must assume an increasingly responsible role in the leadership of business and government.

The development of meaningful programs in the social sciences and humanities, and the adjustment of curricula to provide the time to accomplish the objectives of these programs, present problems which require serious consideration and definitive action by the faculty. These courses should provide challenges and stimuli for broad intellectual growth; they should not merely offer students a cultural veneer. The social sciences and humanities should form an integral part of the total education of engineering students. In describing their place in engineering curricula, the 1956 report of the Humanistic-Social Research Project of ASEE, entitled General Education in Engineering,* states: "They do not stand apart from the rest of the curriculum. They support the scientific-technical training, and are in turn supported by it. They contribute to professional competence not merely in the narrowly vocational sense but in the broad sense of enabling the engineer to see his own activities in their human and social contexts, to understand his own objectives, methods, and problems in relation to the objectives, methods, and problems of men engaged in other activities."

The effective engineer interacts with society whether he knows it or not. If his accomplishments have no effect on society, his career is limited indeed. A major responsibility of engineering education is to see that the engineer's social role is conscious and intelligent. With cataclysmic forces at his command, the engineer who knows little of our society, our culture, our history, may be trained, but he is not educated.

The Engineering College at the University of Illinois has demonstrated leadership in many areas of engineering education, but it is lagging behind in its program in the social sciences and humanities. A thorough study, directed

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* Journal of Engineering Education, ASEE, Vol. 46, No. 8 (April 1956), pp. 619-750.

toward major strengthening of this program, is overdue. To initiate this study, the following recommendations are made:

1. Establish a standing committee in the College of Engineering who, in consultation with representatives from other areas, shall seek to accomplish the selection of courses and course sequences which can provide -- within the time available -- challenging, intellectual experiences in important areas of both the social sciences and the humanities.

2. Establish a minimum requirement of 18 credit hours in the social sciences and humanities, involving work in both areas, exclusive of rhetoric, for all undergraduate curricula offered in the College.